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Interactive comment on "Hypoxia and cyanobacterial blooms are not natural features of the Baltic Sea" *by* L. Zillén and D. J. Conley

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Comment on "Hypoxia and cyanobacterial blooms are not natural features on the Baltic Sea" by Zillen and Conley. The title of the paper is the central message which needs besides other vital statements in the paper a careful consideration. P. 1798: The authors "conclude that blooms of nitrogen-fixing bacteria are not a natural feature of the Baltic Sea as claimed by Bianchi et al. (2000). Blooms of cyanobacteria are likely connected to hypoxia due to release of phosphorus from bottom sediments." 1.) The Bianchi paper clearly states that diazotrophs are natural in the Baltic Sea. 2.) The fundamental point is the chicken–egg problem: Are blooms of diazotrophs caused by hypoxia or is hypoxia caused by diazotrophs? There is evidence that this is a self sustained cycle with a positive feedback (Vahtera et al. 2007). However, the authors

consider only the aspect that blooms of diazotrophs are caused by hypoxia. In contrast, recent observations have shown that local upwelling effects in the Gotland Sea provides enough excess phosphorus from the intermediate layer to the surface which allow the bloom of diazotrophs (Lass et al. 2010). That means hypoxia is not necessary to supply the euphotic zone with excess phosphate!

The authors state that "hypoxia in the Baltic Proper between 2000 and 800 cal yr BP does not show a relationship to any known changes in salinity (Fig. 2)" (p 1788). I wonder how the authors can conclude such a vital statement with accuracy in the order of 100 years, if I read in the legend of Fig. 2 that the age error is $\pm$500 years. In addition, various reconstructions of climate during the last 1000 years show an increase of rain from 1250-1800 during winter time (Glaser 1995, Hennig 1904). As consequence, the lower salinity allowed vertical convection of the water column and long-term stable ventilation of the sea bed (Leipe et al. 2008). It is hard to believe that this can be addressed to population decrease.

A central argument is that hypoxia (in the deep basins) during the Medieval Warm Period was caused by increased eutrophication. There are two arguments against this statement: 1.) The general circulation of the ocean follows f/h contours which mean for the Baltic Sea that the circulation is parallel to the topography. Therefore, on geological time scales all nutrients entering the Baltic Sea via rivers are transported along the coast and do not reach the central basins (Voss et al. 2005a). Ageostrophic transport normal to the streamlines by eddies cannot play a major role because of the very short spin down time of 4.5 days and the quick quasi-geostrophic adjustment (Voss et al. 2005b). The other means of transport via particles in the bottom nephloid layer can hardly be estimated but is certainly much smaller than the transport along the shore. 2.) The estimated increase in DON input during A.D. 1000 and A.D. 1300 is 9800 kt N, assuming a loss of soil organic nitrogen is approx. 4 tN/ha in 20 years (Fig. 4). This is equivalent to $\sim$32 kt N/yr. The annual mean river runoff into the Baltic Sea is $\sim$430km3. That is a concentration of DON from the rivers of 5μmol/L which the authors call “increasing eutrophication”. This concentration is in the order of almost pristine rivers today. On the other hand, the input is DON is only partly bio-available. A concentration of 5μmol/L of DON and a circulation parallel to the coast cannot cause or drastically increase hypoxia in the deep basins.

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